Psychological Review
1968, Vol. 75, No. 5, 421–441

STIMULUS MEANINGFULNESS AND PAIRED-ASSOCIATE TRANSFER:

AN ENCODING VARIABILITY HYPOTHESIS[1]

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The role of stimulus meaningfulness (M) in single-list and transfer situations and in proaction and retroaction paradigms is explicated with the help of an encoding-variability hypothesis, which states that analyzable nominal stimuli are variably encodable and hence may be perceived differently on different occasions. This means that in a single-list situation, paired-associate learning will appear to progress more slowly under the more variable functional stimulation of low-M nominal stimuli. It also means that in a negative transfer situation, the 2nd task involves recoding when stimuli are low M, but unlearning when stimuli are high M. New transfer data are presented as verification, and implications for proaction and retroaction are discussed. Throughout, a major role is assigned to stimulus recognition. Also, the present formulation is compared with alternative views.

In an earlier review and synthesis of the verbal paired-associate transfer literature, the present writer concluded that although the effects of certain stimulus variables were relatively clear in the one-list paired-associate task, implications for the two-list, or transfer, situation were not at all clear (Martin, 1965, p. 336). Since that time, some interesting developments have occurred and several relevant experiments have been performed. On the basis of these, a formulation regarding the process by which stimulus meaningfulness (M) affects the acquisition of verbal paired associates, and hence a formulation as to what it is that is transferred to the second task in a transfer paradigm, is not only possible but not inordinately difficult. The formulation that thus emerges, by virtue of the sources of its premises, makes claim to generality over a number of verbal-learning phenomena.

The central thesis of this paper is that as stimulus M varies, there occurs, inversely with M, a concomitant variation in the number of perceptual/encoding responses that can be made to those stimuli. This notion is jointly implicit in two well-known analyses. Underwood (1963) examined the case for cue selection and concluded that learners will associate overt responses with fewer than all of the aspects of the nominal stimuli to the extent that the task and materials will allow it. Shepard (1963), in commenting on Underwood's paper, pointed out that stimulus M may profitably be viewed in terms of the extent to which the learner is capable of analyzing stimuli into components: low-M stimuli are viewed as more fractionable, less integrated than are high-M stimuli. If these two positions are conjoined, it is but a short step to the hypothesis that, nominal constancy

[1] Research and manuscript preparation was supported by Advanced Research Projects Agency, monitored by Air Force Office of Scientific Research, under Contract Nos. AF 49(638)-1235 and AF 49(638)-1736 with the Human Performance Center, Department of Psychology, University of Michigan.

notwithstanding, there exists functional variability in stimulation that is inversely related to M.

That variability ought to be *inversely* related to M is, of course, counter to what is ordinarily meant by M. Traditionally, M is a generic expression for the core intent of such highly correlated variables as whether or not the stimulus elicits an association (Glaze, 1928; Witmer, 1935), how many associations it elicits (Noble, 1952), how much like a word it is (Archer, 1960), and how pronounceable it is (Underwood & Schulz, 1960). Thus high-M verbal units are seen to elicit a greater number of associations and to be better integrated serially than low-M verbal units. The proposition to be entertained here is that although this is how M is traditionally defined, nomothetic use of this definition in analyses of verbal learning is inappropriate. It is true that variations in M, as defined by the attributes listed above, affect paired-associate learning. The intent of this paper is to show that the role of stimulus M in verbal learning is not traceable to these aspects after all, but rather to another aspect of stimuli that relates in an exactly inverse fashion to these aspects.

According to the view to be argued, association activation takes place in two stages: first, a perceptual response produces an encoding; second, the resultant encoding activates an association, if one exists. Our concern is with the elicitation of the perceptual/encoding response, and only secondarily with the subsequent activation of associations by the resultant encoded version of the nominal stimulus. (These latter associations are what produce overt responding and the responses critical to ordinary scalings of M.)

Before turning to the relation between stimulus M and variability in perception/encoding, and the implications of this relation, it is necessary to schematize the components involved in a hypothesis of functional, as opposed to nominal, stimulus variability. Begin by allowing the following idealized schematic representation, where S_H and S_L are, respectively, high- and low-M stimuli, and where r-s is a central event composed of a perceptual response (r) plus the consequent functional encoding (s) of the nominal stimulus S:

$$S_H \rightarrow r\text{-}s,$$

and

$$S_L \rightarrow \begin{cases} \nearrow\ r_1\text{-}s_1 \\ \rightarrow\ r_2\text{-}s_2 \\ \searrow\ r_3\text{-}s_3. \end{cases}$$

Thus whereas S_H (e.g., the word MOP) is seen to have only one possible functional encoding, S_L (e.g., the trigram XOL) is seen to have three possible functional encodings, only one of which will, ordinarily, be assumed to occur at once. The elicitation of a perceptual response by the nominal stimulus, together with the consequent occurrence of an encoded version of that nominal stimulus, will be called the E Phase, or encoding phase, of the total paired-associate process. The elicitation of previously learned associations by the momentary encoded version(s) of the nominal stimulus S, plus whatever new association formation is required in order to learn to respond overtly according to the wishes of the experimenter, will be called the A Phase, or association phase. Consider first the problem of E Phase variability.

E PHASE VARIABILITY

Let $\{r_i\text{-}s_i\}$ be the set of alternative perceptions/encodings elicitable by stimulus S. The first question is: What is the probability density over

this set? In order to answer this question, the set itself must be at least partially specified. The work of Postman and Greenbloom (1967) and others (see Underwood's 1963 review) indicates that a high probability member of the set must be the initial letter in the case of stimuli that are alphabetic configurations. This means, immediately, that the probability density over the set $\{r_i\text{-}s_i\}$ is in general not rectangular. Also, to have this much in hand is to know that determination, or at least partial determination, of the distribution of density is not impossible. For example, an incomplete distribution in terms of letter members of alphabetic stimuli can be constructed from the results of an experiment by Yum (1931). Even though this aspect of the characterization of the E Phase must remain somewhat indefinite pending execution of some rather sophisticated research, it is easy to demonstrate, as will be seen below, that ordinarily the distribution is not degenerate about a single member of $\{r_i\text{-}s_i\}$. But more importantly, the premise of perceptual/encoding variability can be usefully evoked without precise specification of distribution characteristics.

The second question is: What happens to the distribution of probability over the set $\{r_i\text{-}s_i\}$ with repetition? To answer this question, two cases must be considered: the case where repetition is of the stimulus-familiarization variety and the case where repetition is that which occurs in paired-associate learning. In consideration of the former case, where stimuli are rehearsed independently of paired-associate learning, it is clear that pure familiarization does not alter the density characteristics of $\{r_i\text{-}s_i\}$ vis à vis the association-formation process (the A Phase). Schulz and Martin (1964) have shown that 30 stimulus-familiarization trials have the same effect on subsequent paired-associate learning, at all levels of stimulus M, as do 30 trials of familiarization on trigrams that do not become stimuli in the paired-associate task; the relevant-irrelevant familiarization factor did not interact with stimulus M. Thus, although 30 familiarization trials were observed to reduce differences, over four levels of M, in recallability of the trigrams that were to become stimuli, this differential effect was not transferred to the paired-associate task. In another experiment, Martin (1966) forced one group of learners to rehearse aloud the complete trigram stimulus during the interval between stimulus presentation and response presentation on study trials in a study-test paired-associates task. Another group was forced to count backwards during the interval. The magnitude of the deleterious effect of counting backwards, however, was not different over the four levels of stimulus M used; there was no interaction between stimulus M and interval activity. Thus it is concluded that manipulation of stimulus availability *in the sense of stimulus recallability* does not affect the A Phase differentially over levels of M, which therefore implies that independent familiarization with a nominal stimulus does not alter the distribution of probability density over $\{r_i\text{-}s_i\}$, at least not in a way that changes the availability of one alternative encoding relative to another for purposes of incorporation into an overt-response-producing association. An important corollate conclusion that is easy to lose sight of is that stimuli are processed quite differently in the two experimental situations where they are to be recalled and where they are to elicit functional representations sufficient for signaling adaptive, overt behavior. Where recall

is required, it is most probable that associations are formed among the several encoded elements of a given stimulus; but when the stimulus serves only to signal a response, it is less probable that, except incidentally, the various elements become associated.

In consideration of the possible changes in the probability density over $\{r_i\text{-}s_i\}$ when repetitions are in the context of ongoing paired-associate learning, several experimental results point toward the conclusion that the distribution in fact changes, first toward degeneracy about the selected functional version of the nominal stimulus, and then toward inclusion of additional, alternative encodings. The clearest example of this research is the experiment of James and Greeno (1967). Eight compound stimuli were paired with eight digits. The compounds consisted of a word on the left and a CVC on the right. The words and CVCs were 100% and 10% Archer (1960), respectively. Separate groups of learners were taken to criteria of 4/8, 8/8, and 8/8 plus 10 additional trials. Then a new paired-associate task was initiated wherein the stimuli were the components of the compound stimuli of the first task. Five reinforced trials were given on these 16 transfer pairs. The result of interest is that whereas the proportion word stimuli to which no transfer errors were committed increased from .29 to .60 over the first two degrees of learning, the corresponding proportions for CVC stimuli remained fixed at the very low rate of .06. Thus even after meeting a 4/4 criterion, functional encoding had concentrated on the word component of the compound. Only after overlearning did the CVC components of the original-task-stimuli begin to acquire cue function: after meeting an 8/8 + 10 criterion, the proportion CVC components that were error free in the transfer task was .25. These results are from Experiment I in the James-Greeno (1967) report. Their remaining two experiments, though incorporating additional controls, show the same effect. According to James and Greeno, "the most straightforward interpretation of these results is that *S*s attend to stimuli in a selective manner during learning, and then relax the selective mechanism after the list has been learned [p. 82]."

In conjunction with the foregoing report, it is important to note (with James & Greeno, 1967; and with Postman & Greenbloom, 1967) that with learning, and certainly with overlearning, associations may form among the components of any given stimulus. Thus in the James-Greeno experiment, improved performance on the CVC components during the transfer task may be traceable to mediation through the word components. This possibility, however, is contingent upon relaxation of the selective process, which relaxation allows the processing of the CVC components necessary for the suggested intraitem association formation. Thus, mediation via intrastimulus associations should be viewed as a hypothesis that is complementary to the encoding variability hypothesis.

To summarize the analysis thus far, it is concluded that nominal stimuli are variably encodable and that the probability density over the alternative encodings shifts toward degeneracy early in learning and becomes more platykurtic with overlearning. The hypothesis that low-M stimuli are encodable in more different ways than are high-M stimuli will be substantiated later in the paper.

Before turning to the A Phase (after which we will return to the

E Phase in more detail) it is imperative to point out that to postulate a shifting distribution of probabilities for the members of the set $\{r_i\text{-}s_i\}$ as learning proceeds is to invite still a further analysis that reveals the mechanism of such shifting. The present writer has attempted a conditioning analysis wherein the r in r-s is seen as a differentially conditionable response (Martin, 1967a), and Martin, Melton, and Head [2] have educed experimental evidence toward the inference that alternative encodings can mutually inhibit one another in accordance with a history of differential conditioning. This view is consonant with the facts arising from studies of the time course of certain electrical signatures of the conditioning process, both simple and differential (e.g., Grastyán, 1961; Smythies, 1966, Ch. 5). So-called dominant foci evolve during conditioning that have as their most relevant characteristic inhibitory depression of surrounding, related cortex. With overconditioning, this contrastive picture relaxes without detriment to responding. Collateral suppression of alternative stimulus encodings, with consequent dominant focusing on a single functional aspect, is precisely what is here presumed to occur in the E Phase.[3]

[2] E. Martin, A. W. Melton, and S. Head, Intraunit interference and short-term memory, in preparation.

[3] Magoun (1963) refers to a "dominant focus in learning, conceived as a central core of excitation with an inhibitory surround [p. 123]." This plausibly originates from the pattern of central excitation and surround inhibition characteristic of many afferent systems (Fuster, 1961; Mountcastle, 1961) and agrees with the view that "orienting is a function of the enhanced contrast produced by collateral inhibition" [Douglas & Pribram, 1966, p. 199]." For further details on the importance of contrastive or surround inhibition in perception and learning, see Fair (1965), who argues that inhibitory feedback loops "serve to establish foci of perceptual attention [p. 34]" by heightening the excito-inhibitory contrast between alternative perceptions: "Given an input which includes learned, or adaptively significant, components, feedback from central stations such as temporal association cortex to cortical prime receiving areas may act to select those components from a matrix of less relevant sense-data [p. 49]." The proposed nature of the E Phase is modeled on such views as these.

A PHASE

Given that the nominal stimulus S can be variably encoded, the question that now arises is: To what is the overt response associated? On the assumption that the density over $\{r_i\text{-}s_i\}$ degenerates during early learning, the answer must be that the overt response becomes associated with the functional encoding that consistently recurs (the $r_i\text{-}s_i$ to which most of the probability shifts). An immediate implication of this position is that if after an appreciably strong association between the encoding s_i and the overt response R has evolved, should encoding s_j, $j \neq i$, happen to be elicited, R should not materialize. For if the stimulus of the moment is not perceived as it was earlier, then the learner can hardly treat the stimulus of the moment as a signal to emit the response he learned to that stimulus earlier. Consider the following schematization:

$$S \rightarrow \begin{cases} r_1\text{-}s_1 \rightarrow R \\ r_2\text{-}s_2 \\ r_3\text{-}s_3 \end{cases}$$

Through learning, the $r_1\text{-}s_1$ member of $\{r_i\text{-}s_i\}$ has acquired elicitative control over R. In the event that the learner happens, on some subsequent occasion, to encode S as, say, $r_3\text{-}s_3$, the probability of R should be no more than "chance." As it turns out, this prediction has been verified and replicated by Martin (1967b, 1967d).

The logic of Martin's experiments rests on the premise that if the learner views (encodes) the nominal stimulus S differently on Trial $n + 1$ than he did on Trial n, he will fail to recognize the S of Trial $n + 1$ as the S of Trial n. Using the study-test method of paired-associate learning, he aurally presented, on study trials, eight trigram-digit pairs for silent study at a 2-second rate. On each test trial, the eight study-trials stimuli were randomly intermixed with 16 new trigrams and presented at a 6-second rate. To each trigram, be it a study-trials stimulus or a filler trigram, the learner had to make two responses: First, he had to press one of two buttons, thereby indicating whether or not he recognized the trigram as a study-trials stimulus; second, he had to emit a digit response, the first one to come to mind. In both experiments (1967b, 1967d), it was found that although recognition memory for the study-trials stimuli increased with practice, whenever the learner failed to recognize a given study-trials stimulus the probability of a correct response fell to the chance level. This phenomenon obtained irrespective of the number of times the learner had responded correctly on previous test trials (1967d). Moreover, in a supplementary report, Martin (in press) showed that false recognition of filler trigrams depended significantly upon whether or not the filler trigram in question had its first letter in common with a study-trials trigram, and that given false recognition of such a filler trigram, the probability of emitting the digit response that went with the corresponding study-trials trigram increased with trials in the same manner as did correct responding to actual study-trials trigrams.

The import of these experiments is that an overt response is caused by the encoded, functional version of the nominal stimulus. More specifically, not any encoded version will do; rather it must be an encoded version with which the overt response has become associated. And more specifically yet, a given overt response can be elicited by its causal central representation even when that representation is evoked by a nominal stimulus that is different from the nominal stimulus that underlay the original $s_i \rightarrow R$ association formation.

It is also noteworthy that in the foregoing experiments, recognition of study-trials stimuli began in the 60–70% range on Test-Trial 1 and thereafter increased toward an asymptote. There is little doubt that all subjects (*S*s) clearly heard all stimuli, on every study trial, as they came over the earphones. Each *S* therefore made, perforce, a perceptual response of some sort to each stimulus. That these perceptual responses were variable, especially in early trials, is therefore evidenced by the number of nonrecognitions. In other words, the steady decline in number of nonrecognitions of study-trials stimuli can be used to infer that variability in functional representation of nominal stimuli declines and therefore that as trials accumulate, the A Phase of the total process progresses from receipt of variable toward receipt of constant functional stimulation.

Thus the A Phase of paired-associate learning is simple and straightforward; it is almost entirely characterized by what happens in the E Phase, for it is what happens in the E Phase that dictates the functional stimulus for the association formation that takes place in the A Phase. Moreover, Martin (1967b) has shown that stimulus recognition, which is assumed to be a response measure capable of indexing consistent encoding, is

not affected by the presence or absence of strong, stable associations with overt responses, thereby suggesting that the machinations of the E Phase are not regulated by success or failure in the A Phase.

It is important to make clear that the last point of the preceding paragraph is not a contradiction of the conclusion of the preceding section, wherein it was stated that the density over $\{r_i\text{-}s_i\}$ shifts over trials in a paired-associate task. What is assumed is the following: As paired-associate trials proceed, selective encoding becomes less variable, this irrespective of whether or not the experimenter has rigged the learning situation so that A-Phase association formation is forced into lability. It is as if the mode of operation of the E Phase is set by the strictures of the task imposed, while the A Phase proceeds as best it can in a single mode of operation, namely, simple rote association formation between the overt, designated response and whatever functional stimuli the E Phase provides.

MORE ON THE E PHASE

To return to the central matter of stimulus M, one might suppose from the foregoing analysis that stimulus-M effects reside entirely in the E Phase. Indeed, if M indexes the number of possible alternative encodings, and if it is the selective processing of the E Phase that provides the A Phase with a functional stimulus, it would appear reasonable to infer that stimulus M exerts its effects only on the recognition process that appears to be the necessary antecedent to association activation.

Before attending to the matter of possibly isolating in the E Phase the effects of stimulus M on verbal learning, the role of M in the E-Phase process alone will be documented. In an experiment by Martin and Melton (Martin, 1967c), the Shepard-Teghtsoonian (1961) method of measuring recognition memory was combined with a between-groups manipulation of trigram M. Over a sequence of 320 stimulus presentations, 160 different trigrams were presented twice each. The behavior under study was *S*'s ability to recognize a trigram on its second occurrence. The number of other trigrams intervening between the two occurrences was either 1, 3, 6, 15, or 30. All 160 trigrams were either CCCs or CVCs and either low, medium, or high M. Intralist formal similarity did not vary over levels of trigram M! Not surprisingly, high-M trigrams were easier to recognize than low-M trigrams, this whether the data are expressed in raw frequencies, in a form corrected for false-recognition tendencies, or in terms of the d' measure of information-processing language. And the number of intervening items had its expected detrimental effect. The more important aspect of the data, however, is the fact that the false-positive rate for low-M trigrams markedly exceeded that for high-M trigrams: The tendency to falsely recognize new trigrams on their initial occurrences rose to higher levels under low-M than under high-M conditions; indeed, toward the end of the experimental session, the likelihood of falsely identifying a new trigram as already presented was twice as high for low-M as for high-M trigrams.

Suppose the number of different ways a high-M stimulus can be encoded is n_H and the number of ways a low-M trigram can be encoded is n_L, with $n_H < n_L$. For example, and for simplicity of argument, imagine that MOP may be encoded only as MOP ($n_H = 1$), whereas XOL may

be encoded either as X, L, or XL ($n_L = 3$). Thus, under the high-M condition, the functional units accumulated in memory over initial and test occurrences are easily discriminated. This is because no trigram is de facto repeated, and under the high-M condition the trigrams are assumed stored in memory more or less intact. Under the low-M condition, however, the functional units that accumulate with presentations are frequently indistinguishable both among themselves and from any given newly encoded trigram. This is because under the low-M condition, only fragments of trigrams are assumed stored and there is in fact high similarity among trigram fragments. Altogether, then, stimulus M is seen to affect the E Phase in two ways: Owing to perceptual fragmentation and hence incomplete encoding, recognition is poorer and false-positive tendencies are stronger for low-M than for high-M stimuli. Given the earlier conclusion that stimulus recognition is functionally prior to association activation, both of these effects can be expected to impede the total paired-associate process where such verbal units are used as stimuli. At any rate, we thus conclude that low-M stimuli are encodable in more different ways than are high-M stimuli.

In the experiment on the role of stimulus recognition in paired-associate learning reported above (Martin, 1967d), stimulus M was varied within lists. As can be seen by consulting the original report, M had a significant effect on stimulus recognition. But it also had a significant effect on the probability of a correct response *given* stimulus recognition. This latter effect would seem to deny that the action of stimulus M can be isolated in the E Phase. However, rigorous application of the encoding-variability hypothesis suggests otherwise: To the extent that one encoding occurs more frequently than another encoding during acquisition, there is an appreciable likelihood that whereas recognition may occur to either, correct responding may reliably occur only to the former. The likelihood of this state of affairs is greater when the stimuli are low M than when they are high M. This would therefore produce, spuriously, an apparent effect of stimulus M in the A Phase. In other words, with low-M stimuli there are, owing to the existence of alternative encoding possibilities, more different processing routes via which recognition might ensue than there are processing routes via which correct responding might ensue. In the absence of a distinction between the E and A Phases, one could erroneously gain the impression that stimulus M affects association formation. Accordingly, it is not a theoretic error to conclude tentatively that the effects of stimulus M reside only in the E Phase.

It is of interest to ponder the following possibility, a possibility that endures as long as the foregoing hypothesis is tenable; namely, that all functional encodings are equally tractable in the association-formation process. That is, what difference should it make in the A Phase whether the functional version of the nominal stimulus provided by the E Phase originates from a high- or a low-M trigram? Of what use is cue selection to a learning organism if it does not buy the organism an advantage over having to utilize a complete, unfractionated stimulus? Although the perceptual/encoding variability hypothesis is sufficient to explain stimulus-M effects in single-task paired-associate settings, direct experimental verification of the equal tractability hypothe-

sis will not be easy. Given the demonstration, however, its explanative utility will be significant; for example, the so-called unitary-vs.-incremental issue becomes sensible only upon knowing the variability and tractableness of functional stimuli.

The author has been confronted by others with the possibility that the above analysis of recognition is logically incompatible with the earlier analysis of what prior stimulus familiarization implies for subsequent paired-associate learning. Recall that on the basis of earlier work (e.g., Schulz & Martin, 1964), it was concluded that simple familiarization does not affect the probability distribution over alternative perceptual/encoding responses, and therefore cannot affect paired-associate learning differentially according to stimulus M. Recall also that it has been argued (*a*) that stimulus recognition is a necessary antecedent to association activation and (*b*) that stimulus recognition is greatly affected by M according to the proposed encoding-variability hypothesis. Keeping in mind these points, note the following: Initial exposure in the recognition task (which clearly affects subsequent *recognition* according to M level, which recognition, in turn, is assumed critical for association activation) is precisely what occurs in familiarization prior to paired-associate learning (which familiarization does *not* affect paired-associate learning differentially according to stimulus M). Has the theory herein proposed spawned an internal contradiction? The answer is "no" for the following reasons.

In the familiarization situation, which requires recall of the stimuli, the mode of operation of the E Phase is seen as not involving selective encoding of particular aspects of the stimuli presented, but rather a more or less uniform encoding of those aspects to the end that the stimuli became serially integrated and hence verbally reproducible. Consequently, the familiarization procedure is assumed not to render a particular perceptual/encoding response more probable than another. But at the same time, the familiarization procedure does impose ample experience with numerous (perhaps all) of the possible encodings of any given stimulus, and thereby should facilitate recognition of the familiarized stimuli in the subsequent paired-associate task. The resolving question, however, is: To which of these, or how many of these, does a given response become associated, and to what relative strengths? To the extent that the E Phase does not settle upon a consistent encoding during familiarization, the association-activation power of any one encoding is weak during early paired-associate learning owing to its infrequency of co-occurrence with the response term. Thus, prefamiliarization of stimuli cannot transmit an advantage to the paired-associate stage because prefamiliarization does not fix a particular encoding. To be sure, stimulus recognition is clearly facilitated by prefamiliarization; but until the E Phase stabilizes its output to the A Phase, the total paired-associate process remains at a greater disadvantage the greater the encoding variability (that is, the lower is stimulus M). In short, familiarization does nothing by way of selective encoding, and hence does not affect the process assumed to underlie stimulus-M effects in paired-associate learning.

Now, what about the fact that in the familiarization experiment it made no difference whether the trigrams that were the stimuli in the paired-associate task were or were not the ones familiarized prior to the paired-

associate task? The answer is that in both cases, no prior selection among alternative encodings of the paired-associate stimuli occurred: This is the case for familiarized trigrams according to the argument given just above; this is the case for the nonfamiliarized trigrams because the learner has never seen them before. No disadvantage accrues in the irrelevant-familiarization condition because, as in the relevant-familiarization condition, the occurrences of a particular encoding in either condition has the same probability, on any given *paired-associate* trial, of having been previously experienced (on an earlier trial) in conjunction with the designated response. Thus the suggested contradiction is in fact not a contradiction: the contradiction disappears when it is realized that neither the familiarization nor the recognition procedure causes the E Phase to operate selectively.

TRANSFER

The picture that emerges of what is produced in a single-list paired-associate task is that of an association of an overt response with, ideally, a single one of several alternative encodings of the nominal stimulus. This means that according to the numerosity of alternative functional versions of the nominal stimulus, there exist alternative routes through which new responses can become associated with the nominal stimulus in subsequent transfer tasks. This also means that to the extent that there are few, or no, alternative encodings, association of a new response with an old nominal stimulus must involve extinction, or unlearning of the old $s \rightarrow R_1$ association and acquisition of a new $s \rightarrow R_2$ association. Thus, for example, in the nominal A-B, A-Br paradigm, one has a functional paradigm that approaches the A-B, C-B when the stimuli are low M, but a functional paradigm that approaches the A-B, A-Br when the stimuli are high M. The implications of this view for proactive and retroactive phenomena are straightforward and will be discussed at the end of this paper, but to date have been only minimally explored and verified (Bryk & Kausler, 1966).

In keeping with the arguments of the preceding paragraph, a paired-associate transfer experiment was conducted wherein stimulus M was manipulated.[4] Two nominal paradigms were used: the A-B, A-Br and the A-B, C-B. The latter was deemed the proper specific- and nonspecific-effects control for the former on the basis of an earlier analysis of the association-formation and response-learning aspects of transfer paradigms (Martin, 1965). The prediction is that although ease of first-list acquisition will faithfully reflect the usual effects of stimulus M, transfer to the second task in the A-B, A-Br paradigm will be markedly more negative for high-M than for low-M stimuli, both absolutely (compared with first-task performance) and relative to the A-B, C-B control.

Method

Design. A 2 × 2 design was used wherein the two levels of stimulus M and the two paradigms were all varied between *S*s. There were four successive tasks: (*a*) the first list of six pairs, A-B, was learned to a criterion of two successive perfect trials, which criterion will hereafter be denoted 2(6/6); (*b*) the second list, either A-Br or C-B, was learned to a 2(6/6) criterion; (*c*) the first list, A-B, was relearned to a 2(6/6) criterion; and (*d*) the stimuli just seen, the A's, were free-recalled.

Lists. All lists were made up of six CVC-digit pairs. Two lists of CVCs, ostensibly equivalent, were constructed for each of the

[4] The able assistance of Mark Steinberg is acknowledged.

two levels of M. The two high-M lists were uniformly 100% Archer (1960): ZIP, JOY, MUD, CAT, KEN, PIN; and HOW, RAT, GUN, BET, VAN, LIZ. The two low-M lists each averaged to 21% Archer (1960): ZOB, JYS, MEF, CAQ, KIW, PUV; and HIF, RYX, GEC, BUH, VAB, LOJ. Each of these four lists was paired in two different ways with the digits 1–6.

Within the limits of paradigm restrictions, each possible Task 1-Task 2-Task 3 sequence of lists was used equally often. More specifically, for every utilization of a given list in the second task of the A-B, C-B paradigm, that list was used equally often in the second task of the A-B, A-Br paradigm.

Subjects. In all, 80 University of Michigan undergraduate females volunteered for paid ($1.25) participation. Twenty were assigned to each of the four experimental conditions (two transfer paradigms, two levels of stimulus M).

Procedure. Each *S* was tested individually. He was told that each trigram would appear in the memory-drum window for 2 seconds, during which time he must emit a digit response between 1 and 6, inclusive. At the end of 2 seconds, the shutter was lowered for 2 seconds and a green lamp was lighted if he guessed the correct number. If he guessed the wrong number, or if he guessed the correct number but did not emit it before the 2-second stimulus-exposure period ended, the lamp was not lighted. (The digit responses per se were never shown to *S* nor uttered by the experimenter.) Upon reaching the 2(6/6) criterion in Task 1, all *S*s were told, "Your task this time is exactly the same, to learn to say the digits 1 through 6 to six trigrams." Those in the A-Br condition were told further that the trigrams would be the same as before but that "the digits will be paired up with the trigrams differently." Those in the C-B condition were told further that "the six trigrams are different from the six trigrams you just had." Upon reaching the 2(6/6) criterion on this, the second, task, all *S*s were told that their third task was to "simply relearn the list of the first task." Having reached the 2(6/6) criterion on this A-B relearning task, *S* was asked to "write down on this card all of the trigrams you can remember from the list we've just been going through." The experimental session ordinarily required less than half an hour.

Results and Discussion

Task 1. The mean numbers of trials to criterion in the A-B, C-B paradigm was 15.55 and 13.70 for low-M and high-M stimuli, respectively. The corresponding numbers for the A-B, A-Br paradigm are 16.30 and 12.10. Thus the usual single-list effect of stimulus M was observed.

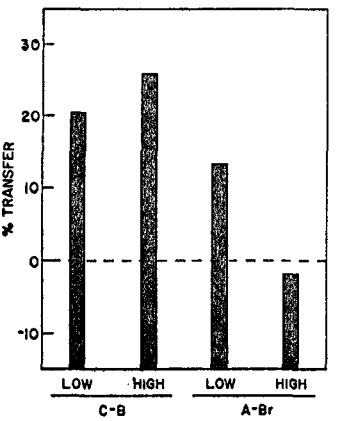

FIG. 1. Mean percent transfer from Task 1 to Task 2.

Task 2. The mean number of trials to criterion on Task 2 in the A-B, C-B paradigm was 9.95 and 7.95 for low-M and high-M stimuli, thus showing a nonspecific gain over Task 1 but maintaining the superiority of learning under high-M as opposed to low-M stimulation. In the A-B, A-Br paradigm, the mean number of trials to criterion on Task 2 was 11.90 and 11.90 for low-M and high-M stimuli, thus indicating a gain over Task 1 in the case of low-M stimuli but no change in the case of high-M stimuli.

The percent transfer from Task 1 to Task 2 was calculated for each *S* individually by the formula $100(T_1 - T_2)/T_1 + T_2)$, where T is trials to criterion. The means of these for the four experimental conditions are shown in Figure 1. In absolute terms, whereas the percent transfer in the A-B, A-Br paradigm with low-M stimuli was 13.2, for high-M stimuli it was −1.9. The appropriate comparison, however, is

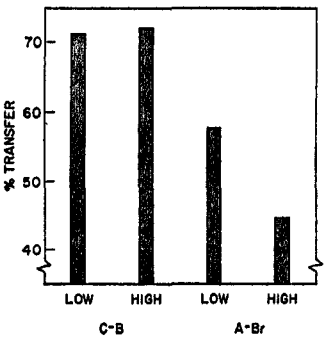

FIG. 2. Mean percent transfer from Task 1 to Task 3.

with the A-B, C-B control paradigm. As can be seen in Figure 1, the difference between the two paradigms under low-M stimulation is $20.4 - 13.2 = 7.2$. This difference is not statistically significant, $t = .63$, $df = 38$, $p > .50$, thereby indicating little or no negative transfer in the A-B, A-Br paradigm with low-M stimuli. The difference between the two paradigms under high-M stimulation, however, is $25.8 + 1.9 = 27.7$, which is highly significant, $t = 3.51$, $df = 38$, $p < .01$. Thus extensive negative transfer occurs in the A-B, A-Br paradigm, but only with high-M stimuli. Another way of summarizing this result is to say that with low-M stimuli, the nominal A-B, A-Br paradigm approaches, functionally, the A-B, C-B paradigm.

It is also important to report that in the A-B, A-Br paradigm, the variability among the individual-*S* transfer scores was three times greater for low-M than for high-M stimuli, $F = 3.23$, $df = 19/19$, $p < .01$. This result points to the conclusion that although transfer in the A-B, A-Br paradigm is markedly less negative with low-M stimuli, the underlying responsible process is more variable, a predictable conclusion on the view that with low-M stimuli there is greater encoding, and hence greater recoding, variability than is the case with high-M stimuli. By comparison, in the A-B, C-B paradigm it was the high-M condition that yielded the greater variability; the difference, however, was very slight and statistically unreliable, $F = 1.40$, $df = 19/19$, $p > .20$.

The foregoing transfer results are precisely those predicted on the assumption that low-M stimuli can be encoded in a greater variety of ways than can high-M stimuli, and hence can provide more alternative recoding routes in a negative-transfer situation. In contrast, owing to the assumed absence of either very many or any alternative encodings, high-M stimuli place the learner at a serious disadvange, forcing him to unlearn instead of allowing him to recode.

Task 3. The mean number of trials to criterion for A-B relearning in the A-B, C-B paradigm was 3.00 and 2.32 for the low-M and high-M conditions; in the A-B, A-Br paradigm, the corresponding numbers are 4.35 and 5.10. Again, the effect of stimulus M is in opposite directions for the two paradigms. The mean transfer scores [over individual *S*s, using $100(T_1 - T_3)/(T_1 + T_3)$] for the four experimental conditions are shown in Figure 2. It will be noted that except for absolute level, the pattern of Figure 2 is very similar to the pattern of Figure 1. Thus in the A-B, A-Br paradigm, it is easier to get back to the original, Task 1 pairings when the stimuli are low M than when they are high M, again suggesting recoding of low-M stimuli but unlearning to high-M stimuli.

Stimulus recall. The demonstrated utility of low-M stimuli in negative-transfer situations notwithstanding, they remained significantly less available in the sense of recallability than did the high-M stimuli. Of the 40 *S*s in the two high-M conditions, only five

failed to recall all six trigrams perfectly, and these five missed one each. For the two paradigms separately, the mean number stimuli (the A's) correctly recalled were 5.90 and 5.85 out of six for paradigms A-B, C-B and A-B, A-Br, respectively. The corresponding means for the low-M conditions were 3.60 and 3.50. These facts serve to emphasize the conclusion stated earlier, namely, that stimuli to be recalled are encoded differently than are stimuli whose sole function is to signal an overt response. The unavailability of low-M stimuli relative to high-M stimuli also further affirms the conclusion that low-M stimuli are processed in a more analytic, fractionated fashion than are high-M stimuli.

Other observations. There are two additional findings from the present transfer experiment that from the point of view of this writer are puzzling. First, it turns out that the correlations between trials to criterion on Task 1 and trials to criterion on Task 2 shadow the percent-transfer results. In progressing from left to right over the conditions listed along the horizontal axis of Figure 1, the correlations are .28, .38, .26, and .03. None of these is significantly different from zero, and none differs significantly from any of the others. But the close relation with percent transfer ought to mean something to someone. Second, it turns out that for the A-B, A-Br paradigm, the number of perseveration errors committed in Task 2 is significantly higher for low-M stimuli than for high-M stimuli. Out of 618 errors to high-M stimuli on Task 2, 84, or 13.6%, were responses that would have been correct were the pairings of Task 1 still in effect. The corresponding figures for low-M stimuli are 128 out of 608, or 21.0%. The difference between 13.6% and 21.0% is highly significant in the statistical sense, $z = 3.17$, $p < .001$. This result is contradictory to what might be expected from the encoding-variability hypothesis.

That the main results of the transfer experiment just reported are reliable was learned from a report of Merikle's unpublished MA thesis by Battig (1966, pp. 223–226). Merikle manipulated stimulus and response M independently in each of several transfer paradigms. The results were clear: not only were the transfer effects reported above substantiated (with even larger differences), but similar effects were observed also in the A-B, A-D paradigm.

[As an aside, it might be pointed out that Merikle and Battig (1963) have demonstrated less negative transfer in the A-B, A-Br paradigm with low-M materials when stimulus and response M are *co*varied. This result may be viewed as a composite of the effects of stimulus M, as described in this paper, and response M, as discussed elsewhere (Martin, 1965). Both stimulus and response M are directly related to ease of single-list learning, but inversely related to ease of transfer-list learning. These two variables thus have similar effects on the total paired-associate process, but for different reasons: the former by virtue of encoding variability, the latter by virtue of the criterional requirement of integrating the response elements for verbal output.]

Before turning to alternative interpretations, and thence the matters of proaction and retroaction, there is one further point to be made with respect to application of the encoding-variability hypothesis to the transfer situation. Begin with the following question: If learning in Task 1 produces a leptokurtic density about a single member of the set $\{r_1\text{-}s_1\}$, then how can a hypothesis about recoding variability be applied to Task 2 learning? The easiest answer is that even though Task 1

produces a leptokurtic density about a particular r_i-s_i, that density is not completely degenerate and is less leptokurtic for low-M than for high-M stimuli. A second, and perhaps independent, answer is that the nonreinforcements, or errors, that occur at the outset of Task 2 serve to break up to some degree the concentration of probability established by Task 1 learning. On the view that it is differentially-conditioned collateral inhibition that underlies the reduced probability of alternative encodings, it makes reasonably good sense to say that the nonreinforcements that initiate Task 2 learning cause disinhibition and thereby reintroduction of encoding variability. The latter answer is consonant with the well-known facts that errors in discrimination learning and introduction of reversal learning both elicit previously habituated orientation reactions (e.g., Grastyán, 1961; Lynn, 1966, Ch. 5). However, there are no data that allow a defensible choice between these two answers; more than likely, what is in order is a combination of the two rather than a choice.

Associative Probability Theory

The contribution to verbal learning theory made by the traditional understanding of how stimulus M affects paired-associate learning is nicely captured in what is called associative probability theory (Mandler, 1967, pp. 32–33; Underwood & Schulz, 1960, pp. 45–49). The idea is that stimuli giving rise to a greater number of associations are more viable in a learning situation than are stimuli giving rise to fewer associations. This is because "the greater the number of associations that extend from a word, the more likely that the word will, through mediation of one of these existing associations, form an association with a new paired item [Glanzer, 1962, p. 34]." This view is sufficient to explain the simple effects of stimulus M in single-list tasks: it predicts that pairs with high-M stimuli will be easier to learn than pairs with low-M stimuli, where M refers to scaled number of associations elicited.

What does associative probability theory predict with respect to ease of learning in the second task of a negative-transfer paradigm? If *S* is allowed to utilize an alternative elicited association, it predicts less negative transfer when the stimuli are high M than when they are low M. This is because there are more alternative associations in the former than in the latter case. When such an experiment is conducted, however, the opposite result obtains: There is less negative transfer with low-M, not high-M, stimuli. If *S* is not allowed to utilize an alternative elicited association in second-task learning, then second-task learning should not be affected by stimulus M. This version of associative probability theory is also denied by the transfer data reported in the preceding section.

Aside from outright failure in the transfer situation, associative probability theory is deficient on two other scores. First, it has limited plausibility on two counts: (*a*) It would appear that the probability of making such postulated mediative contacts between the stimuli and responses that occur in controlled, experimental settings is miniscule. And if not miniscule, hardly of sufficient magnitude to yield observed stimulus-M effects. What is required by associative probability theory is an elicited association such that rote association formation between it and an arbitrary response (designated by the experimenter) is easier than association formation between the nominal stimulus and that arbitrary response. (*b*) Associative probability

theory gives rise to what is called the interference paradox (Underwood & Schulz, 1960, p. 46): If alternative elicited associations exist, they should serve to interfere with the total learning process. This last objection could be obviated by proposing a mechanism that selectively inhibits these interfering alternatives. But to so proceed would preclude with finality any hope of an associative-probability-theory explanation of the transfer results.

The second score on which associative probability theory is deficient can be stated as follows: The failures this theory experiences in the transfer situation are compounded in the proaction and retroaction situations. Proaction and retroaction will be discussed later. Suffice it to say here that were it the case that high-M stimuli provide more alternative association routes to a given response than do low-M stimuli, retroactive interference should be less with high- than with low-M stimuli. This expectation is denied both by the Task 3 results of the transfer experiment reported above and by the results of an experiment by Bryk and Kausler (1966).

STIMULUS DISCRIMINABILITY

The encoding-variability hypothesis is intimately related to the discriminability hypothesis put forward by Gibson (1940):

> The hypothesis asserts that a major necessity of verbal learning is the establishment of *discrimination* among the items to be learned, and that this process of discriminating is actually a fundamental part of what is called generally the learning process [p. 197].

She further argues that M is "one characteristic of a verbal or visual item which serves to *differentiate* it from other items, [where] generalization is at a minimum for meaningful material [p. 222]." Correspondingly, the hypothesis of the present paper says that perceptual/encoding variability is at a minimum for meaningful (high-M) material. The question is: How does perceptual/encoding variability relate to discriminability? The answer is: Perceptual/encoding variability is the basis of discriminability. Several systematic comments on this claim are in order.

The situation is not as simple as Gibson imagined; two distinct cases must be treated. Begin by considering two paired-associate lists. Two pairs constitute each list so that for one list the stimuli are MOB and ROB and for the other they are MZQ and RZQ. Following Shepard (1963), we will posit that the two high-M stimuli are processed in a unitary manner, a single and different perceptual/encoding response occurring to each, and that the two low-M stimuli are processed in a fractionated manner. Suppose, for the sake of argument, that for each of the two low-M stimuli there are exactly three equally likely encoding responses; and further, again only for the sake of argument, assume that the encodings are the comprising letters themselves. As *S* starts through the list with high-M stimuli, the probability that his encoding of MOB will be identical to his encoding of ROB is zero. But as he starts through the list with low-M stimuli, the probability that his encoding of MZQ will be identical to his encoding of RZQ is $(2/3) \times (1/3) = .22$. Thus with probability .22, *S* will do two things: first, he will functionally confuse the second stimulus with the first; and second, he will add an increment of association strength between a common functional version of both stimuli and the overt response that goes with the second nominal stimulus. This latter must perforce provide interference against the corresponding increment of association strength between that common aspect of both stimuli and the

overt response that goes with the first nominal stimulus. In short, the encoding variability over the alternative functional versions of the two low-M stimuli is responsible for what can be called failure to discriminate MZQ and RZQ, to the end that learning is impeded.

Consider now the case where there are no common letters between the two low-M stimuli. In such a case, the probability that *S*'s encoding of one of the stimuli will be identical to his encoding of the other is zero, as in the case where the two stimuli are high M. But when a stimulus is high M, its single encoding will recur with certainty on the next trial; hence any previously acquired association strength between it and the designated overt response will be transferred to good effect. This stands in contrast to the situation where the stimuli are low M: even though the encoding on Trial 1 of a given one of the stimuli may be unique to that stimulus, its probability of recurrence on Trial 2 is decidedly less than unity, for an alternative encoding of that stimulus may occur. This means that should an alternative encoding occur, the associative strength acquired on Trial 1 will not transfer to Trial 2. Thus even when formal similarity among stimuli is controlled, paired-associate performance with low-M stimuli is impeded.

With respect to discriminability in this latter case (where none of the low-M stimuli has any obvious aspect in common with any of the others), what is loosely referred to as stimulus indiscriminability might better be referred to as poor stimulus *identifiability*. Thus it is the present writer's opinion that what is fundamental is stimulus identifiability (recognition), and that failure to discriminate is a special case of this. One obtains failure to discriminate when *S* identifies one stimulus on the basis of a perceptual/encoding response that is also the perceptual/encoding response by which he identifies another stimulus. The link between this view and arguments made earlier in this paper is that recognition constitutes identification. The step from stimulus presentation to stimulus identification/recognition is called the "Höffding step," which will be documented later.

PROACTION AND RETROACTION

From the position that what occurs in Task 2 of a negative-transfer paradigm is stimulus recoding when possible (e.g., low-M stimuli) and unlearning when recoding is not possible (e.g., very high-M stimuli), explication of the role of stimulus M in proaction and retroaction paradigms is fairly straightforward. Let Task 1 be A-B learning, let Task 2 be A-D learning, and let Task 3 be free responding to the A stimuli after a delay of some length. To the extent that stimulus recoding is possible in the A-D, or second, task, the result of A-D learning will be a change in the probability density over $\{r_i\text{-}s_i\}$, with the D response associated with an encoding of A that is different from the encoding of A to which the B response had become associated by virtue of the first, or A-B, task. These relations are schematized in Figure 3, which depicts

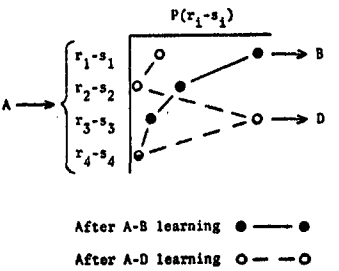

FIG. 3. Probability of $r_i\text{-}s_i$ to nominal S at end of A-B and A-D learning, where B is associated with s_1 and D is associated with s_3.

invented probability distributions over the set $\{r_i\text{-}s_i\}$ as produced by A-B and A-D learning when the stimuli are low M.

When the Stimulus A is presented in Task 3, which response, B or D, can occur depends upon which member of the set $\{r_i\text{-}s_i\}$ occurs. To the extent that $P(r_3 - s_3) > P(r_1 - s_1)$, there can be no evidence of proactive interference from A-B learning, which means that the *possibility* of proaction depends first on the probability of the earlier encoding. In a more general sense, proactive interference can occur only to the extent that the probability density over $\{r_i\text{-}s_i\}$ is not degenerate at $r_3 - s_3$ (see Figure 3) at the time of testing (Task 3). It is important to note that proactive interference with the overt emission of D must begin with activation of an alternative encoding, whether or not that alternative encoding brings about an identifiable overt response. Thus, proaction originates in the E Phase. (It can occur in the A Phase in the form of competing associations only when two or more encodings are elicited at once, the possibility of which is not denied by the present formulation. A further comment on this below.)

As Task 3 is delayed, no shift in the probability of Response D can occur unless there is an underlying change in the probability density over $\{r_i\text{-}s_i\}$. It is completely plausible that any shift in attention between Task 2 (A-D learning) and Task 3 (free responding to the A's) may to some degree disrupt the distribution set up by Task 2. The point of interest is that it is with low-M stimuli that such a shift in $r_i\text{-}s_i$ probabilities is most likely. This is because for low-M stimuli there are more alternative encodings that could be externally disinhibited. What this means is that with lengthening delay of Task 3, one should observe a greater decline in the probability of D when the stimulus is low M than when it is high M, and hence a greater recovery of the probability of B.

When viewed in this way, it becomes clear that spontaneous recovery of Response B and regression of Response D are bound phenomena underlain by the learner's stimulus-encoding processes, and hence the incidence of these effects should be more marked for stimuli of greater encoding variability. Unfortunately, research on recovery and regression has not included stimulus M as a variable. At best, the author can lamely point out that for a Task 3 delay of 24 hours, Silverstein (1967) found recovery of B responses using CVC-adjective pairs (low-M stimuli) and Koppenaal (1963) found no change using adjective-adjective pairs (high-M stimuli). Kamman and Melton (1967) also confirm the present prediction that spontaneous recovery of first-task responses should occur when the stimuli are low M: using CVC-adjective pairs, they observed absolute recovery over a 26-minute retention interval. As is evident, systematic research on the role of stimulus M in proaction and retroaction should be of considerable interest.

It may also be worthwhile to comment on the fact that in Task 3, learners are often capable of emitting both B and D upon presentation of the nominal stimulus A. From the point of view of the present formulation, this must mean that at the time of recall testing, Stimulus A was encoded at least twice via reperception.[5] If one assumes that each encoding takes time, it should be possible to prevent double responding by a stimulus presentation

[5] Production of both B and D in Task 3 may also be explained in terms of a mediating association between the Task 1 encoded version of A and the Task 2 encoded version of A.

that is very rapid and is followed by erasure of all momentarily perseverating traces (perhaps after the manner of Averbach & Coriell, 1961). By the same argument, plus the assumption that the probability density over $\{r_i\text{-}s_i\}$ is not rectangular, short exposure of stimuli during acquisition should reduce the effects of stimulus M in single-list and negative-transfer situations and accordingly reduce proactive and crystallize retroactive effects.

As a final comment on retroaction and proaction, it must be recognized that in the early trials of A-B learning, during which time several alternative encodings of the same nominal stimulus may occur, the response B probably acquires dependency, however weakly, upon encodings other than s_1 of Figure 3. There is no reason to suppose that these associations are extinguished. This is because during A-B learning their occasional activation of B produces confirmation or reinforcement. Moreover, upon introduction of the A-D task, the association between s_1 and B will undergo extinction on those occasions prior to consistent recoding of A as s_3 (see Figure 3). This means that even with low-M stimuli there must exist a certain amount of unlearning in the second task of proaction and retroaction situations. However, these are no more than modulating considerations: The point remains that whereas this unlearning is only partial or incomplete where recoding is possible, it must be complete where recoding is not possible.

OVERVIEW

The purpose of this paper is to press the case for serious consideration of the hypothesis that perceptual/encoding variability underlies stimulus-M effects in paired-associate learning and thereby determines what is available for transfer to new situations. The relation between stimulus M and encoding variability is argued to be an inverse one: There are more alternative encoding possibilities for low-M than for high-M stimuli. This view is consonant with the known effects of stimulus M on single-list paired-associate learning and with the known effects of stimulus M on recognition. A new experiment demonstrated that given these effects in the single-list situation, the encoding-variability hypothesis predicts the outcome of varying stimulus M in a negative-transfer situation. The same experiment was then shown to deny associative probability theory.

The present formulation bears certain resemblances to an earlier formulation by Goss (1955), who argued (*a*) that overt behavior is under the control of implicit, response-produced cues and (*b*) that, in the terminology of this paper, the distribution of probability density over alternative encodings of the nominal stimulus can be manipulated by "the strengthening of responses of looking for the specific parts or part-characteristics which differentiate complex stimuli [p. 26]." Lawrence's (1963) impressive theoretic analysis of the functional stimulus is also similar, except for certain terminological aspects. Lawrence assumes

> that the subject makes an implicit, covert response . . . [that] operates in interaction with the sensory input. It is called a coding response because in interaction with the sensory input it produces a new event or code item which then represents the stimulus [p. 189].

Lawrence's coding response may be written as r, and the resulting stimulus-as-coded (s-a-c) as s. He also makes the following two statements, both of which indicate basic agreement with the present formulation: "It is assumed that the consequence of . . . inconsistent reinforcement is a change in the coding

response [p. 190]" and "Even though the same stimulus object occurs in two successive tasks, it is conceivable that the individual shifts from one coding response to another . . . new learning then can occur without the need for extinguishing the previous associations [p. 211]." It is the intent of the present paper to show that these ideas have considerable integrative power over a number of verbal phenomena.

Another model against which the present formulation bears comparison is McGuire's (1961) multiprocess model of paired-associate learning. In hypothesizing a route of behavior control from the nominal S to the overt R, he considers first a link that associates S with "a mediating, stimulus-producing response, r. This r is a partial representation of the S to which it becomes connected, encoding some aspect of the S which discriminates that S from the others in the list [p. 335]." Thus McGuire recognized the need for fixating a perceptual/encoding response of some sort. He pointed out that the difficulty of such a fixation can be manipulated by varying either intralist stimulus similarity (which he did in his experiment) or by varying the number of irrelevant dimensions that are descriptive of the set of stimuli. The formulation of the present paper extends McGuire's model to take into account the encoding variability McGuire must have presumed to be not only possible but present, the encoding variability therefore fundamental to his idea that fixation of an encoding response is an indispensable link in the total paired-associate process.

And finally, the present formulation bears on what might be called Höffding's problem. Höffding (1891) defined elementary memory as an interaction between a sensation A and a reproduced trace a. The fusive interaction of A and a was seen by him to constitute recognition. Like McGuire (1961), Höffding schematized the association between the two events A and B in terms of trace mediation: $A \rightarrow a \rightarrow b \rightarrow B$. He then pointed out that in association activation, one must be concerned not only with the availability and strength of the link $a \rightarrow b$, but also, and perhaps more importantly, with the link $A \rightarrow a$. "For whatever states and further effects it [a] may be able to call up, the first condition is that there shall be an instinctive recognition [p. 153]." "In order that A may excite the ideas of B, C, D, with which it usually arises simultaneously in consciousness, it must first, so to speak, establish its identity. Thus A must give rise to a, and only then will a bring with it b, c, and d [p. 157]." Thus Höffding saw that stimulus identification is fundamental to association activation. The problem of encoding uncertainty clearly is not new. (For further discussion of Höffding's problem, see Rock, 1962, and Neisser, 1967.)

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(Received August 7, 1967)